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IMPROVEMENTS IN DRY PUMPS

This invention relates to dry pumps and in particular to the clearing of particulate dirt from dry pumps.

Dry pumps typically comprise non-contacting, self-valving mechanisms and no oil or lubricants in the pumping mechanism. The component parts of these pumps are manufactured to tight tolerances to provide fixed running clearances between components and reduce friction or other reactive forces, which may reduce the efficiency of the pump mechanism. The pumps are used in many manufacturing applications, one of the major of which is semi-conductor manufacture. The pumps are used to provide the very clean, near vacuum environment needed for the manufacture of quality semi-conductor products. The skilled addressee will no doubt be familiar with other common applications of dry pump technology.

Many industries including the semi-conductor industry produce particulate or powderous waste or bi-products which are withdrawn from the manufacturing environment by pumps such as the dry pumps to which this invention relates. In the semi-conductor industry it is usual for manufacturing lines to run twenty four hours a day, thus, dry pumps used in this application are in continuous use except where there is a need for a manufacturing line change or maintenance or repair of the pump. The pumps have an inlet purge function on shut down for evacuating contaminants from the pump mechanism, but these purge functions rarely operate one hundred per cent efficiently and some level of particulate contamination invariably remains within the pump.

Running temperatures for dry pumps in semi-conductor manufacturing lines are typically around 120°C, when the pumps are switched off, they cool to normal room temperature (around 19 °C), the components (such as rotors and stators in the pump mechanism) contract, reducing the running clearances between them and any particulate contaminants present in the

mechanism are compacted in between the contracted components. On restart, where the torque required to overcome the friction caused by the presence of these particulate materials compacted between the components is higher than the operational torque of the pump, start-up failure occurs.

The present invention aims to maintain running clearances of dry pumps and minimise the occurrence of restart failure due to compacted particulate contaminants.

In accordance with a first aspect, the present invention provides a dry pump apparatus comprising;
a pumping mechanism,
a controller for controlling the operation of the pumping mechanism, and
a sensor for sensing the operating temperature of the pumping mechanism wherein the controller is configured to carry out an automated shutdown sequence involving the following steps;
a) ceasing operation of the pumping mechanism
b) monitoring the temperature of the pumping mechanism by means of the temperature sensor
c) at at least one pre-selected temperature interval, initiating operation of the pumping mechanism for a fixed time period so as to purge a proportion of contaminant particulate matter present until a predefined temperature is reached or a predefined time limit has passed.

This pulsed purging method effected by the controller of the dry pump apparatus enables small amounts of contaminant to be evacuated from the pump as it cools so that when the apparatus is cooled to the ambient temperature, there is significantly less particulate contaminant in the pumping mechanism than there would otherwise be. Thus, the particulate material is less compact and frictional forces to be over come on start-up, significantly less. Consequently, the occurrence of failure on restart is significantly reduced.

It will be understood that this pulsed shut down method is what provides the technical improvement in the function of prior art dry pumps. Accordingly, in a second aspect, the invention provides a method for reducing the incidence of restart failure in a dry pump comprising the steps of;

a) detecting the cessation of operation of the pumping mechanism

b) monitoring the temperature of the pumping mechanism after cessation of operation

c) at at least one pre-selected temperature interval, initiating operation of the pumping mechanism for a fixed time period so as to purge a proportion of contaminant particulate matter present until a predefined temperature is reached or a predefined time limit has passed.

The controller of the dry pump apparatus may comprise a microprocessor which may be embodied in a computer, which in turn is optionally programmed by computer software which, when installed on the computer, causes it to perform the method steps a) to c) mentioned above.

In a third aspect therefore the invention comprises a program for a computer which, when installed on the computer, causes it to perform the method steps of;

a) detecting the cessation of operation of the pumping mechanism

b) monitoring the temperature of the pumping mechanism after cessation of operation

c) at at least one pre-selected temperature interval, initiating operation of the dry pump for a fixed time period so as to purge a proportion of contaminant particulate matter present until a predefined temperature is reached or a predefined time limit has passed.

In a fourth aspect, the invention comprises a computer readable carrier medium which carries a computer program which when installed on a computer, causes it to perform the method steps of;

a) detecting the cessation of operation of the pumping mechanism

b) monitoring the temperature of the pumping mechanism after cessation of operation
c) at at least one pre-selected temperature interval, initiating operation of the dry pump for a fixed time period so as to purge a proportion of contaminant particulate matter present until a predefined temperature is reached or a predefined time limit has passed.

The carrier medium may be selected from but is not strictly limited to a floppy disk, a CD, a mini-disc or digital tape.

In one preferred option, the pulsed shut down method is performed at intervals corresponding to regular drops in the internal temperature of the pump apparatus. A suggested temperature drop interval is 10 degrees though this is not essential. The interval may equally be 2 degrees, 30 degrees or anything in between. Appropriate temperature intervals may be selected based on the cooling conditions, the amount of time available for the pulsed shut down process and other factors. Alternatively less regular temperature intervals may be pre-selected. For example a number of small intervals (eg 2 degrees) may be selected for the early part of the cooling period and increasingly larger intervals as the apparatus approaches the predefined "cool" temperature.

The fixed time period of the pulse is again variable and will desirably be selected based on cooling conditions or other practical factors. A fixed time period of between 15 and 45 seconds is suggested, and about 30 seconds considered practical. The fixed time period may be the same for each pre-selected temperature interval, or may be different. For example, the period may be of relatively longer duration at lower temperatures.

The duration of the pulse may be dictated by the apparatus reaching a predefined "cool" temperature, such as the usual room temperature. Alternatively, the method may be performed for a fixed time period

irrespective of the cooling time. In the latter case a duration of about 2 hours is suggested, but not essential.

At the end of each fixed time period of operation of the pump mechanism a separate inlet purge function may be effected by the controller.

In some embodiments, the controller may be configured to cease the pulsed shutdown method when the first of a predetermined temperature or a predefined time limit has been reached.

The dry pump apparatus may be of any known form but one preferred form is a dry pump which includes a claw type rotor. Dry pumps of this form are known in the prior art. Briefly, they include a pair of shafts each carrying a pair of claw shaped rotors which rotate in opposite directions to trap and compress gas flowing along the axis of the shafts between each claw pair. During each complete rotation of the shafts, first the inlet port of each claw pair is exposed then both the inlet and outlet are isolated, finally the outlet is exposed allowing trapped gas to be expelled. In these arrangements, the controller controls the rotation of the shafts.

Since many existing dry pump apparatus include a controller which runs software for operating the pump, the invention can conveniently be implemented by uploading the computer program of the invention to the existing controller. Thus the control can be configured on shutdown automatically to perform the pulsed shut down method of the invention.

For the purposes of exemplification, some embodiments of the invention will now be described with reference to the following Figures in which:

Figure 1 illustrates the problem of particulate contamination addressed by the present invention
Figure 2 illustrates how the present invention affects the process illustrated in figure 1

Figure 3 illustrates the method of the invention in a time line format
Figure 4 illustrates the method of the invention in graph form.

Figure 1 shows schematically the pumping mechanism of a dry pump apparatus 1 having a drive unit D driving a pair of shafts 1a, 1b each carrying a stator Sa, Sb and a rotor Ra, Rb. Figures 1(a), 1(b) and 1(c) show the relationship between a rotor R and a stator S of the pumping mechanism. Figure 1(a) illustrates the arrangement between the rotor R and stator S at normal running temperature of the pump. The running clearance between the stator S and rotor R is shown as d_1. As shown in Figure 1(b) as the apparatus cools, the running clearance d_2 is reduced due to contraction of the shaft carrying the stator S and rotor R. As shown in Figure 1(c), powder P which may have accumulated on the surface of the stator S, can become compacted in the reduced clearance between the stator S and rotor R. This compaction results in a frictional force to be overcome by the rotor R if it is to rotate on restart of the apparatus. If sufficient torque is not provided to the rotor R to overcome this frictional force, then start up failure occurs.

Figure 2 shows in sequential order (Figures (a) to (f)) a stator S and rotor R cooling from running temperature (Figure 2(a)) to gradually cooler temperatures (Figures 2(b) - 2(f)). In each of Figures 2(a) to 2(e), it can be seen that there is a layer of settled powder P settled on the surface of the stator S. It will also be noted that the clearance between the stator S and rotor R gradually decrease as the temperature of the apparatus falls. Between Figures 2(b) and 2(c), 2(c) and 2(d) and 2(e) and 2(f), the pump is briefly activated and a proportion of the powder P is evacuated. Thus when the final cooling temperature is reached (Figure 2(f)) the quantity of powder is minimal and insufficient to cause any great counter force against the torque of the rotor on restart. Thus the occurrence of start-up failure on restart is reduced.

Figure 3 shows a time line of the pulsed shut down method of the invention. As can be seen, in tandem with the pulse sequence shown in the top line, a booster associated with the pump may be configured to run for a brief period after initial shutdown to aid in removal of any powderous contaminant within the pump mechanism to reduce the initial quantity which may settle on the stator while the pumping mechanism is inactive. As can be seen form the top line of the figure, after shutdown, the pump remains active for around 30 seconds and then is dormant for a period (Delta T= 10deg) while the internal temperature of the mechanism, monitored by the controller falls to 10 degrees (centigrade) below the normal operating temperature. When the period is complete, the pump is activated for 30 seconds then again held dormant until a further fall of 10 degrees in the monitored temperature. The cycle is repeated until either the monitored temperature is 40°C, or the time elapsed since the start of the sequence is two hours.

Figure 4 illustrates the method of Figure 3 in graphical form. The vertical axis corresponds to the monitored temperature of the pumping mechanism, the horizontal axis corresponds to the passage of time. The thick, black curved line shows the monitored temperature gradually falling. The thinner, pulsed line shows active and dormant periods of the pumping mechanism during the cooling process.

It is to be understood that the foregoing represents just a few embodiments of the invention, others of which will no doubt occur to the skilled addressee without departing from the true scope of the invention as defined by the claims appended hereto.